Population-based reference values for the 1-min sit-to-stand test

Strassmann, Alexandra ; Steurer-Stey, Claudia ; Lana, Kaba Dalla ; Zoller, Marco ; Turk, Alexander J ; Suter, Paolo ; Puhan, Milo A

Abstract: OBJECTIVES: To determine reference values for the 1-min sit-to-stand (STS) test in an adult population. METHODS: Cross-sectional study nested within a nationwide health promotion campaign in Switzerland. Adults performed the STS test and completed questions on demographics and health behavior. RESULTS: 6,926 out of 7,753 (89.3 %) adults were able to complete the STS test. The median number of repetitions ranged from 50/min (25-75th percentile 41-57/min) in young men and 47/min (39-55/min) in young women aged 20-24 years to 30/min (25-37/min) in older men and 27/min (22-30/min) in older women aged 75-79 years. CONCLUSIONS: The reference values support the interpretation of 1-min STS test performance and identification of subjects with decreased lower body muscular strength and endurance.

DOI: https://doi.org/10.1007/s00038-013-0504-z

Originally published at:
Strassmann, Alexandra; Steurer-Stey, Claudia; Lana, Kaba Dalla; Zoller, Marco; Turk, Alexander J; Suter, Paolo; Puhan, Milo A (2013). Population-based reference values for the 1-min sit-to-stand test. International Journal of Public Health, 58(6):949-953.
DOI: https://doi.org/10.1007/s00038-013-0504-z

Int J Public Health (2013) 58:949–953
DOI 10.1007/s00038-013-0504-z

BRIEF REPORT

Population-based reference values for the 1-min sit-to-stand test

Alexandra Strassmann · Claudia Steurer-Stey · Kaba Dalla Lana · Marco Zoller · Alexander J. Turk · Paolo Suter · Milo A. Puhan

Received: 20 May 2013 / Revised: 9 August 2013 / Accepted: 14 August 2013 / Published online: 24 August 2013

Abstract
Objectives To determine reference values for the 1-min sit-to-stand (STS) test in an adult population.
Methods Cross-sectional study nested within a nation-wide health promotion campaign in Switzerland. Adults performed the STS test and completed questions on demographics and health behavior.
Results 6,926 out of 7,753 (89.3 %) adults were able to complete the STS test. The median number of repetitions ranged from 50/min (25–75th percentile 41–57/min) in young men and 47/min (39–55/min) in young women aged 20–24 years to 30/min (25–37/min) in older men and 27/min (22–30/min) in older women aged 75–79 years.
Conclusions The reference values support the interpretation of 1-min STS test performance and identification of subjects with decreased lower body muscular strength and endurance.

Keywords Lower body strength · Endurance · Interpretation · Reference values · Sit-to-stand test

A. Strassmann · M. A. Puhan (✉)
Institute of Social and Preventive Medicine, University of Zurich, Hirschengraben 84, Room HRS G29, 8001 Zurich, Switzerland
e-mail: milo.puhan@ifspm.uzh.ch

C. Steurer-Stey · K. D. Lana · M. Zoller
Institute of General Practice, University of Zurich, Zurich, Switzerland

A. J. Turk
Zürcher Höhenklinik Wald, Faltiberg-Wald, Switzerland

P. Suter
Department of Internal Medicine, University Hospital of Zurich, Zurich, Switzerland

Introduction

Muscular strength and endurance are important indicators of current health and among the strongest predictors of mortality in both healthy individuals and patients with chronic diseases (Bautmans et al. 2004; Kasymjanova et al. 2009; Myers et al. 2002; Pinto-Plata et al. 2004; Puhan et al. 2013; Roger et al. 1998). Measuring muscular strength and endurance is important to evaluate mobility and to detect low exercise capacity in healthy individuals and patients. It provides a basis for counseling on effective training and rehabilitation options that address this important and modifiable risk factor for health outcomes.

An important barrier to widespread testing of muscular strength and endurance is the resources needed. For example, the incremental exercise and 6-min walk tests are highly valuable tests but they require infrastructure and personnel, which are not always available in primary and population-based settings. The 1-min sit-to-stand (STS) test, in contrast, is a widely implementable measure of lower body muscular strength and endurance (Bohannon 1995), which captures the number of times a subject can stand up and sit down on a regular chair in 1 min. Lower body muscular strength and endurance play an important role in everyday activities (Janssen et al. 2002). The STS test can be performed in any health care setting since the test requires minimal equipment (conventional chair and stopwatch) and is simple to perform for most subjects and takes little time. The STS test is reproducible, shows high correlations with other exercise capacity tests such as the 6-min walk test or stair climbing (Bohannon 2012; Jones et al. 1999; Ozalevli et al. 2007) and provides prognostic information (Puhan et al. 2013).

However, limited evidence is available to interpret STS test performance. Reference values are necessary to identify subjects with decreased lower body muscular strength and endurance compared with sex- and age-matched individuals (Solberg 2004). Available STS test reference data mostly refer to an elderly and selected United States population or to different types of STS tests (Bohannon 2006; Rikli and Jones 1999; Ritchie et al. 2005). No reference values are available for Europeans or for the entire age range of adults. Therefore, our aim was to determine reference values and equations for the 1-min STS test in a European adult population.

Methods

Study design

This cross-sectional study was nested within a nationwide health promotion campaign in Switzerland organized by *Lunge Zurich* (Zurich, Switzerland) from April 2010 to June 2012. *Lunge Zurich* (see http://www.lunge-zuerich.ch) is a not-for-profit health organization that offers preventive and therapeutic services for lung diseases to the general population and people affected by lung diseases. The aim of the health promotion campaign was to raise awareness for "chronic obstructive pulmonary disease" among the Swiss population. A bus (the so-called "Luftibus"), equipped with different medical devices operated by trained health professionals of the *Lunge Zurich* visited 42 communities across the entire country and invited people from those communities to volunteer to get a free spirometry test, complete a questionnaire and perform additional tests including the STS test. Participants were informed about their test outcomes and counseling was offered about potential next steps (e.g. available smoking cessation programs and evaluation by a general practitioner) whenever indicated. Participants were offered to decline that their data were stored anonymously in the database of the health promotion campaign of *Lunge Zurich*. The Ethics Committee of the Canton of Zurich (Switzerland) waived approval since anonymous data collection did not require approval of the study by an ethical committee.

Population

We included the adult population (aged 20–79 years) of all participants of the national health promotion campaign of *Lunge Zurich*, i.e. we did not focus on patients with chronic diseases nor did we exclude them.

Measurements

For the 1-min STS test trained study nurses asked the participants to sit down on a chair (height 46 cm, same chair used for all participants) without arm rests, to keep their feet parallel (the legs not touching the chair) at least as wide apart as their hips (Spinae illiaca anterior superior) and to have the arms hang down loosely or to put them on their hips (Ozalevli et al. 2007). The assisted use of the arms was not allowed during the STS test. To fully stand up the legs had to be straightened entirely (i.e. complete knee extension) and to sit down the chair had to be touched by the buttocks. The study nurses instructed the participants to complete as many sit-to-stand cycles as possible within 60 s at self-paced speed. They informed the participants when 30 and 15 s were left, respectively, and counted the number of fully completed STS cycles (i.e. not completed or incorrectly performed STS cycles were not counted). The study nurses motivated all individuals to perform the STS test but did not put any pressure on participants with musculoskeletal or neurological conditions, who felt unable to complete the STS test.

In addition to testing lower body muscular strength and endurance, the participants completed a questionnaire that asked about sex, age, smoking status and level of perspiration during physical activity. For smoking status, participants indicated if they were a "never smoker", "ex-smoker" or "current smoker". As measure of the level of physical activity, participants were asked to indicate how much they sweat ("not at all" (no perspiration), "weak", "moderate" or "strong") when performing physical activities. Finally, the study nurses measured height (in cm) and weight (in kg) of each participant to calculate the body mass index (BMI, kg/m^2).

Statistical analysis

We excluded participants with missing STS tests from the analyses since these participants had musculoskeletal or neurological conditions and felt unable to complete the STS test (i.e. data not missing at random). Thus the references values refer to a population that is able to complete the STS test. In order to deal with missing data for smoking status (4/6,926 missing), BMI (2/6,926 missing) and perspiration level (159/6,926 missing) we used tenfold multiple imputation where sex, age, smoking status, BMI and activity level (frequency, intensity and perspiration) served as predictors.

We began the analyses by comparing the study population with the Swiss population to judge how well the study population represented the general population in terms of age, sex, BMI and smoking status (Swiss Federal Statistical Office, see http://www.bfs.admin.ch/bfs/portal/de/index/themen.html). Since there is no general consensus on the descriptive statistics to be used for reference values we calculated selected percentiles (2.5, 25, 50, 75 and 97.5th) stratified for sex and 5-year age groups that described the distribution of STS test performance. We did not calculate percentiles if >20 % of participants were unable to complete the STS test within a 5-year age group. In order to generate easy-to-use reference equations we used multiple linear regression analysis with STS test performance as outcome and sex, age and smoking status as predictors. We also explored how much information would be gained if BMI and level of perspiration were added to the regression model. We used SPSS for Macintosh (version 19) for all analyses.

Results

Study population

We included 6,926 out of 7,753 participants (89.3 %) in the analysis who completed the STS test. The sample consisted of 52.3 % women and the median age of all participants was 54.0 years. Table 1 shows that the sex and smoking status distributions were similar to those of the general population. The age groups 60–79 were somewhat overrepresented while the 20–39-year-olds were underrepresented in the study sample. We found more people with overweight in the sample than in the general population.

Reference values for the STS test

With exception of the two oldest age groups (80–84 years and 85–89 years) where more than 20 % were unable to complete the STS test (39.3 % of men and 42.1 % of women of 80–84 years, respectively, and 25.0 % of men and 26.0 % of women of 85–89 years, respectively), we calculated the distribution of STS test performance for each sex and age group (Table 2). The median number of repetitions ranged from 50/min (25–75th percentile 41–57/min) in men aged 20–24 years to 30/min (25–37/min) in men aged 75–79 years. In women, the median was 47/min (39–55/min) in age group 20–24 years and 27/min (22–30/min) in age group 75–79 years. STS test results for men were generally higher (on average 3 more repetitions) than for women. In both men and women, we observed a constant decline of performance across age groups.

Reference equations for the STS test

Table 3 presents two models that predict STS test performance. Model 1 includes easily available information on sex, age and smoking status that were all statistically significant predictors and explained 24 % of the STS test variance. We found an average decline of 1.84 repetitions per 5 more years of age. Both ex-smokers and current smokers showed lower STS test performance than never smokers but the difference was more pronounced for current smokers. Model 2 also includes BMI and level of perspiration during physical activity and increased the explained variance to 28 %.

Discussion

In this study, we determined sex- and age-stratified reference values for the STS test for a European adult population up to the age of 79 years. Age, sex, smoking status, BMI and level of perspiration during physical activity together predicted STS test performance moderately (Cohen 1992). These reference values and equations provide guidance for the interpretation of STS test performance in individuals.

Healthy individuals with below-average STS test performance could be informed about the risks associated with decreased lower body muscular strength and endurance and receive counseling on how to improve them through supervised or unsupervised training programs. Since below-average values can be defined differently, we calculated a number of percentiles. For example, values below the 25th percentiles are below average but may or may not be considered to be abnormal. If the number of STS repetitions falls below the 2.5th percentile lower body muscular strength and endurance can be considered to be severely impaired confidently (Wright and Royston 1999). For patients with existing disease, reference values are valuable to judge the impact of a disease on lower body muscular strength and endurance. For example, a primary care cohort of patients with chronic obstructive pulmonary disease showed that the median number of repetitions was 17/min at enrolment (Puhan et al. 2013). Most patients were between 60 and 70 years of age who, based on the reference values provided by this study, should be able to perform 35 repetitions in 1 min. Thus patients with chronic obstructive pulmonary disease achieved, on average, less than 50 % compared with members of the same sex and age from the general population. Also, the reference equations support interpretation of STS test results for individuals. The STS test result observed for an individual can be compared with the reference value provided by the reference equation. For example, a 65-year-old woman who stopped smoking had 25 repetitions during the STS test, whereas the population average predicted by the reference equation is 34 (i.e. 74 % of the predicted value).

Our study is the largest and the first population-based study to provide reference data for the STS test for a European adult population. Comparisons with other studies are difficult because previous studies used other types of STS tests, did not stratify the results for sex and age as major determinants of exercise capacity and were small or not population-based (Lord et al. 2002; Ozalevli et al.

Table 1 Comparison of the characteristics of the participants ($n = 6{,}926$) and the Swiss population characteristics ($n = 5{,}929{,}833$, aged between 20 and 79) (Switzerland, 2011)

Variable	Sample (%)	Swiss population (%)
Sex		
Male	47.7	49.7
Female	52.3	50.3
Age category (years)		
20–29	9.2	17.2
30–39	11.3	18.6
40–49	19.5	21.7
50–59	20.9	18.3
60–69	24.0	14.6
70–79	15.1	9.6
Body mass index (BMI)[a]		
Underweight (BMI < 18.5)	2.6	3.5
Normal weight (18.5 ≤ BMI < 25)	50.7	59.2
Overweight (25 ≤ BMI)	46.7	37.3
Smoking status[b]		
Never smoker	53.9	50.9
Ex-smoker	23.0	21.2
Current smoker	23.1	27.9
Perspiration during physical activity[c]		
No perspiration	6.2	–
Weak	28.6	–
Moderate	44.1	–
Strong	21.1	–

Data are derived from the Swiss Federal Statistical Office

[a] Swiss population consisted of $n = 18{,}473$, aged between 15 and 75+ (conducted in 2007)

[b] Swiss population consisted of $n = 18{,}473$, aged from 15 years (conducted in 2007). In the sample smoking status was weighted by residence (canton)

[c] Population data for perspiration during physical activity were not available

Table 2 Reference values of the sit-to-stand test ($n = 6{,}926$) (Switzerland 2010–2012)

Age group (years)	Number of STS repetitions									
	Men					Women				
	p2.5	p25	p50	p75	p97.5	p2.5	p25	p50	p75	p97.5
20–24	27	41	50	57	72	31	39	47	55	70
25–29	29	40	48	56	74	30	40	47	54	68
30–34	28	40	47	56	72	27	37	45	51	68
35–39	27	38	47	58	72	25	37	42	50	63
40–44	25	37	45	53	69	26	35	41	48	65
45–49	25	35	44	52	70	25	35	41	50	63
50–54	24	35	42	53	67	23	33	39	47	60
55–59	22	33	41	48	63	21	30	36	43	61
60–64	20	31	37	46	63	20	28	34	40	55
65–69	20	29	35	44	60	19	27	33	40	53
70–74	19	27	32	40	59	17	25	30	36	51
75–79	16	25	30	37	56	13	22	27	30	43

p5 2.5th percentile, *p25* 25th percentile, *p50* median, *p75* 75th percentile, *p95* 97.5th percentile

2007; Rikli and Jones 1999; Ritchie et al. 2005). Nevertheless, the reference data for the 30 s STS test from a small US elderly population showed about half the number of repetitions for different age and sex strata as the 1-min STS reference data in our study.

Strengths of the present study include the large sample size and the recruitment of the sample from different parts of an entire country. Also, although our study population was not randomly selected from the general population, the study population was remarkably similar to the Swiss general population. A limitation of this study is that we only included people from Switzerland. Only studies in other European countries or beyond will show how much the reference values for the STS test differ across countries.

Table 3 Multiple regression analysis for variables predicting sit-to-stand test performance (Switzerland 2010–2012)

Model and variable	Sit-to-stand test				
	R^2	Unstandardized coefficients		Standardized coefficients	p value
		β	SE	β	
Model 1	0.24				
(Intercept)		58.64	0.51		<0.001
Sex (0 = female, 1 = male)		3.31	0.25	0.14	<0.001
Age (per 5 more years)		−1.84	0.01	−2.37	<0.001
Smoking status[a]					<0.001
Ex-smoker		−0.96	0.31	−0.04	0.002
Current smoker		−3.14	0.33	−0.11	<0.001
Model 2	0.28				
(Intercept)		68.21	0.98		<0.001
Sex (0 = female, 1 = male)		4.04	0.25	0.17	<0.001
Age (per 5 years)		−1.69	0.01	−2.18	<0.001
Smoking status[a]					
Ex-smoker		−0.73	0.30	−0.03	0.015
Current smoker		−3.18	0.33	−0.11	<0.001
Body Mass Index (per 5 more BMI)		−2.83	0.03	−0.99	<0.001
Perspiration during activity[b]					
Weak		1.97	0.55	0.08	<0.001
Moderate		3.10	0.53	0.13	<0.001
Strong		3.34	0.57	0.12	<0.001

SE Standard error

[a] Reference category: never smoker

[b] Reference category: no perspiration

In conclusion, the 1-min STS test is simple to perform for an adult population below the age of 80 years and may be used widely to determine lower body muscular strength and endurance in an adult population. The reference values from a large population reported here support the interpretation of STS test performance and identification of subjects with low lower body muscular strength and endurance.

References

Bautmans I, Lambert M, Mets T (2004) The six-minute walk test in community dwelling elderly: influence of health status. BMC Geriatr 4:1–9

Bohannon RW (1995) Sit-to-stand test for measuring performance of lower extremity muscles. Percept Mot Skills 80:163–166

Bohannon RW (2006) Reference values for the five-repetition sit-to-stand test: a descriptive meta-analysis of data from elders. Percept Mot Skills 103:215–222

Bohannon RW (2012) Measurement of sit-to-stand among older adults. Topics Geriartic Rehabil 28:11–16

Cohen P (1992) A power primer. Psychol Bull 112:155–159

Janssen WGM, Bussmann HBJ, Stam HJ (2002) Determinants of the sit-to-stand movement: a review. Phys Ther 82:866–879

Jones CJ, Rikli RE, Beam WC (1999) A 30-s chair-stand test as a measure of lower body strength in community-residing older adults. Res Q Exerc Sport 70:113–119

Kasymjanova G, Correa JA, Kreisman H, Dajczman E, Pepe C, Dobson S, Lajeunesse L, Sharma R, Small D (2009) Prognostic value of the six-minute walk in advanced non-small cell lung cancer. J Thorac Oncol 4:602–607

Lord SR, Murray SM, Chapman K, Munro B, Tiedemann A (2002) Sit-to-stand performance depends on sensation, speed, balance, and psychological status in addition to strength in older people. J Gerontol A Biol Sci Med Sci 57:M539–M543

Myers J, Prakash M, Froelicher V, Do D, Partington S, Atwood JE (2002) Exercise capacity and mortality among men referred for exercise testing. N Engl J Med 346:793–801

Ozalevli S, Ozden A, Itil O, Akkoclu A (2007) Comparison of the sit-to-stand test with 6 min walk test in patients with chronic obstructive pulmonary disease. Respir Med 101:286–293

Pinto-Plata VM, Cote C, Cabral H, Taylor J, Celli BR (2004) The 6-min walk distance: change over time and value as a predictor of survival in severe COPD. Eur Respir J 23:28–33

Puhan M, Siebling L, Zoller M, Muggensturm P, ter Riet G (2013) Simple functional performance tests and mortality in COPD. Eur Resp J, pp 1–22. doi:10.1183/09031936.00131612

Rikli RE, Jones CJ (1999) Functional fitness normative scores for community-residing older adults, ages 60–94. J Aging Phys Act 7:162–181

Ritchie C, Trost SG, Brown W, Armit C (2005) Reliability and validity of physical fitness field tests for adults aged 55 to 70 years. J Sci Med Sports 8:61–70

Roger VL, Jacobsen SJ, Pellikka PA, Miller TD, Bailey KR, Gersh BJ (1998) Prognostic value of treadmill exercise testing. Circulation 98:2836–2841

Solberg HE (2004) The IFCC recommendation on estimation of reference intervals. The RefVal program. Clin Chem Lab Med 42:710–714

Wright EM, Royston P (1999) Calculating reference intervals for laboratory measurements. Stat Methods Med Res 8:93–112